

Academic Standards for Mathematics

January 15, 2009 DRAFT
Secondary Standards
Grades 8, 11
Algebra I, Geometry, Algebra II



Pennsylvania Department of Education

SECONDARY STANDARDS
GRADES 8, 11
Algebra I, Geometry, Algebra II

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V. INTRODUCTION

This document includes Mathematics Standards:

- ◇ 2.1. Numbers, Number Systems and Number Relationships
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- ◇ 2.3. Measurement and Estimation
- ◇ 2.4. Mathematical Reasoning and Connections
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- ◇ 2.6. Statistics and Data Analysis
- ◇ 2.7. Probability and Predictions
- ◇ 2.8. Algebra and Functions
- ◇ 2.9. Geometry
- ◇ 2.10. Trigonometry
- ◇ 2.11. Concepts of Calculus

The Mathematics Standards describe what students should know and be able to do in Algebra I, Algebra II, and Geometry courses. They reflect the increasing complexity and sophistication that students are expected to achieve as they progress through school.

With each Standard divided into conceptual strands, this document avoids repetition of learned skills and makes an obvious progression across grade levels less explicit. Teachers shall expect that students know and can apply the concepts and skills expressed at the preceding level. Consequently, previous learning is reinforced but not re-taught.

Students who achieve these mathematical standards will be able to communicate mathematically. Although it is an interesting and enjoyable study for its own sake, mathematics is most appropriately used as a tool to help organize and understand information from other academic disciplines. Because our capacity to deal with all things mathematical is changing rapidly, students must be able to bring the most modern and effective technology to bear on their learning of mathematical concepts and skills.

A glossary is included to assist the reader in understanding terminology contained in the standards. Words in bold faced text are included in the glossary

SECONDARY STANDARDS
GRADES 8, 11
Algebra I, Geometry, Algebra II

2.1. Numbers, Number Systems and Number Relationships					
	2.1.8. GRADE 8	2.1.A1. ALGEBRA I	2.1.G. GEOMETRY	2.1.A2. ALGEBRA II	2.1.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Count and Compare Numbers	2.1.8.A. Model and compare values of integers and rational numbers .	2.1.A1.A. Model and compare values of irrational numbers . M11.A.1.1.1 M11.A.1.1.2 M11.A.1.1.3 M11.A.1.3.1 M11.A.1.3.2	2.1.G.A. Model and compare values of irrational numbers . M11.A.1.1.1 M11.A.1.1.3	2.1.A2.A. Model and compare values of complex numbers .	2.1.11.A. Model and compare values of irrational and complex numbers .
Represent Numbers in Equivalent Forms	2.1.8.B. Represent and use numbers in equivalent forms (e.g., integers , fractions, decimals, percents, exponents , scientific notation , square roots , absolute values).	2.1.A1.B. Use factoring to create equivalent forms of polynomials . M11.D.2.2.2	2.1.G.B. Intentionally Blank	2.1.A2.B. Use factoring to create equivalent forms of polynomials . M11.D.2.2.2	2.1.11.B. Use factoring to create equivalent forms of polynomials .
Concepts of Numbers and Relationships	2.1.8.C. Use ratio and proportion to model relationships between quantities.	2.1.A1.C. Intentionally Blank	2.1.G.C. Intentionally Blank	2.1.A2.C. Intentionally Blank	2.1.11.C. Intentionally Blank

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2.1. Numbers, Number Systems and Number Relationships					
2.1.8. GRADE 8		2.1.A1. ALGEBRA I	2.1.G. GEOMETRY	2.1.A2. ALGEBRA II	2.1.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Place Value	2.1.8.D. Extend place-value concepts to represent large numbers using exponential, scientific, and calculator notation.	2.1.A1.D. Use exponential, scientific, and calculator notation to represent any rational number . M11.A.1.1.2	2.1.G.D. Intentionally Blank	2.1.A2.D. Use exponential, scientific, and calculator notation to represent any rational number . M11.A.1.1.2	2.1.11.D. Use exponential, scientific, and calculator notation to represent any rational number .
Number Theory	2.1.8.E. Apply concepts of prime and composite numbers to calculate GCFs (Greatest Common Factor) and LCMs (Least Common Multiple) of numbers.	2.1.A1.E. Apply the concepts of prime and composite polynomials to determine GCFs (Greatest Common Factor) and LCMs (Least Common Multiple) of polynomials . M11.A.1.2.1	2.1.G.E. Intentionally Blank	2.1.A2.E. Intentionally Blank	2.1.11.E. Apply the concepts of prime and composite polynomials to determine GCFs (Greatest Common Factor) and LCMs (Least Common Multiple) of polynomials .
Concepts and Applications of Operations	2.1.8.F. Understand the concepts of exponents and roots and use the inverse relationships between exponents and roots to determine unknown quantities in equations .	2.1.A1.F. Extend the concept and use of inverse operations to determine unknown quantities in linear and polynomial equations .	2.1.G.F. Intentionally Blank	2.1.A2.F. Understand the concepts of exponential and logarithmic forms and use the inverse relationships between exponential and logarithmic expression to determine unknown quantities in equations .	2.1.11.F. Understand the concepts of exponential and logarithmic forms and use the inverse relationships between exponential and logarithmic expression to determine unknown quantities in equations .

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GRADES 8, 11
Algebra I, Geometry, Algebra II

2.2. Computation and Estimation					
	2.2.8. GRADE 8	2.2.A1. ALGEBRA I	2.2.G. GEOMETRY	2.2.A2. ALGEBRA II	2.2.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Fluency in Basic Facts	2.2.8.A. Intentionally Blank	2.2.A1.A. Intentionally Blank	2.2.G.A. Intentionally Blank	2.2.A2.A. Intentionally Blank	2.2.11.A. Intentionally Blank
Computation	2.2.8.B. Add, subtract, multiply and divide different kinds and forms of rational numbers including integers , decimal fractions, percents and proper and improper fractions.	2.2.A1.B. Intentionally Blank	2.2.G.B. Intentionally Blank	2.2.A2.B. Intentionally Blank	2.2.11.B. Intentionally Blank
Evaluate Numerical Expressions	2.2.8.C. Use the order of operations to evaluate numerical expressions .	2.2.A1.C. Evaluate numerical expressions that include the four basic operations and operations of powers and roots, reciprocals , opposites, and absolute values . M11.A.2.2.1 M11.A.2.2.2 M11.A.3.1.1	2.2.G.C. Intentionally Blank	2.2.A2.C. Evaluate numerical expressions that include the four basic operations and operations of powers and roots, reciprocals , opposites, and absolute values . M11.A.2.1.2 M11.A.2.1.3 M11.A.2.2.1 M11.A.3.1.1	2.2.11.C. Evaluate numerical expressions that include the four basic operations and operations of powers and roots, reciprocals , opposites and absolute values .

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GRADES 8, 11
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2.2. Computation and Estimation					
2.2.8. GRADE 8		2.2.A1. ALGEBRA I	2.2.G. GEOMETRY	2.2.A2. ALGEBRA II	2.2.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Numerical Estimation	2.2.8.D. Estimate the values of irrational numbers and the results from calculations with basic operations of fractions and percents and check the reasonableness of those estimates.	2.2.A1.D. Intentionally Blank	2.2.G.D. Intentionally Blank	2.2.A2.D. Intentionally Blank	2.2.11.D. Intentionally Blank

SECONDARY STANDARDS
GRADES 8, 11
Algebra I, Geometry, Algebra II

2.3. Measurement and Estimation					
	2.3.8. GRADE 8	2.3.A1. ALGEBRA I	2.3.G. GEOMETRY	2.3.A2. ALGEBRA II	2.3.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Concept of Measurement	2.3.8.A. Intentionally Blank	2.3.A1.A. Intentionally Blank	2.3.G.A. Intentionally Blank	2.3.A2.A. Intentionally Blank	2.3.11.A. Intentionally Blank
Units and Tools of Measurement	2.3.8.B. Develop strategies for determining areas and volumes of compound shapes and solids.	2.3.A1.B. Intentionally Blank	2.3.G.B. Intentionally Blank	2.3.A2.B. Intentionally Blank	2.3.11.B. Intentionally Blank
Calculations	2.3.8.C. Calculate volume, surface area, and degrees of angles; calculate circumference and area of circles, and use a measurement formula to solve for a missing quantity.	2.3.A1.C. Find missing quantities in measurement formulas by applying equation solving techniques. M11.A.2.1.1.1	2.3.G.C. Use properties of geometric figures and measurement formulas to solve for a missing quantity (e.g., the measure of a specific angle created by parallel lines and is a transversal).	2.3.A2.C. Intentionally Blank	2.3.11.C. Use properties of geometric figures and measurement formulas to solve for a missing quantity (e.g., the measure of a specific angle created by parallel lines and a transversal).

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2.3. Measurement and Estimation					
2.3.8. GRADE 8		2.3.A1. ALGEBRA I	2.3.G. GEOMETRY	2.3.A2. ALGEBRA II	2.3.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Conversions	2.3.8.D. Perform conversions within the metric system and within the customary system including scale measurements between units of time and between units of temperature.	2.3.A1.D. Intentionally Blank	2.3.G.D. Intentionally Blank	2.3.A2.D. Intentionally Blank	2.3.11.D. Intentionally Blank
Relations	2.3.8.E. Describe how a change in linear dimension of an object affects its perimeter, area and volume.	2.3.A1.E. Describe how a change in the value of one variable in a formula that utilizes linear variables affects the value of the measurement. M11.B.2.3.1	2.3.G.E. Describe how a change in the value of one variable in area and volume formulas affect the value of the measurement.	2.3.A2.E. Describe how a change in the value of one variable in complex formulas affects the value of the measurement.	2.3.11.E. Describe how a change in the value of one variable in a formula affects the value of the measurement.
Measurement Estimation	2.3.8.F. Estimate and verify measurements of rate and mass.	2.3.A1.F. Intentionally Blank	2.3.G.F. Intentionally Blank	2.3.A2.F. Intentionally Blank	2.3.11.F. Intentionally Blank

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2.4. Mathematical Reasoning and Connections					
2.4.8. GRADE 8		2.4.A1. ALGEBRA I	2.4.G. GEOMETRY	2.4.A2. ALGEBRA II	2.4.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Reasoning	2.4.8.A. Draw inductive and deductive conclusions within mathematical contexts.	2.4.A1.A. Demonstrate the capability of justifying any step in an equation solving process by citing an algebraic property	2.4.G.A. Write formal proofs (direct proofs, indirect proofs/ proofs by contradiction , use of counter-examples, truth tables, etc.) to validate conjectures or arguments.	2.4.A2.A. Intentionally Blank	2.4.11.A. Write formal proofs (direct proofs, indirect proofs/proofs by contradiction , use of counter-examples, truth tables, etc.) to validate conjectures or arguments.
Connections	2.4.8.B. Use <i>if...then</i> statements to construct simple valid arguments .	2.4.A1.B. Use <i>if...then</i> format to describe properties and theorems in algebra.	2.4.G.B. Use statements, converses, inverses , and contrapositives to construct valid arguments or to validate arguments relating to geometric theorems.	2.4.A2.B. Use statements, converses, inverses , and contrapositives to construct valid arguments or to validate arguments.	2.4.11.B. Use statements, converses, inverses and contrapositives to construct valid arguments or to validate arguments.

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2.5. Mathematical Problem Solving and Communication					
2.5.8. GRADE 8		2.5.A1. ALGEBRA I	2.5.G. GEOMETRY	2.5.A2. ALGEBRA II	2.5.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Problem Solving	<p>2.5.8.A. Develop a plan to analyze a problem, identify the information needed to solve the problem, carry out the plan, apply estimation skills as appropriate, check whether the plan makes sense, and explain how the problem was solved in grade appropriate contexts.</p>	<p>2.5.A1.A. Develop a plan to analyze a problem, identify the information needed to solve the problem, carry out the plan, check whether an answer makes sense, and explain how the problem was solved in grade appropriate contexts.</p> <p>M11.A.3.2.1</p>	<p>2.5.G.A. Develop a plan to analyze a problem, identify the information needed to solve the problem, carry out the plan, check whether an answer makes sense, and explain how the problem was solved in grade appropriate contexts.</p> <p>M11.A.3.2.1</p>	<p>2.5.A2.A. Develop a plan to analyze a problem, identify the information needed to solve the problem, carry out the plan, check whether an answer makes sense, and explain how the problem was solved in grade appropriate contexts.</p> <p>M11.A.3.2.1</p>	<p>2.5.11.A. Develop a plan to analyze a problem, identify the information needed to solve the problem, carry out the plan, check whether an answer makes sense, and explain how the problem was solved in grade appropriate contexts.</p>
Communication	<p>2.5.8.B. Use precise mathematical language, notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams to explain and interpret results.</p>	<p>2.5.A1.B. Use symbols, mathematical terminology, standard notation, mathematical rules, graphing, and other types of mathematical representations to communicate observations, predictions, concepts, procedures, generalizations, ideas and results.</p>	<p>2.5.G.B. Use symbols, mathematical terminology, standard notation, mathematical rules, graphing, and other types of mathematical representations to communicate observations, predictions, concepts, procedures, generalizations, ideas, and results.</p>	<p>2.5.A2.B. Use symbols, mathematical terminology, standard notation, mathematical rules, graphing and other types of mathematical representations to communicate observations, predictions, concepts, procedures, generalizations, ideas, and results.</p>	<p>2.5.11.B. Use symbols, mathematical terminology, standard notation, mathematical rules, graphing and other types of mathematical representations to communicate observations, predictions, concepts, procedures, generalizations, ideas, and results.</p>

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2.6. Statistics and Data Analysis					
2.6.8. GRADE 8		2.6.A1. ALGEBRA I	2.6.G. GEOMETRY	2.6.A2. ALGEBRA II	2.6.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Collection of Data	2.6.8.A. Understand and apply sampling techniques to gather data including simple random sampling and convenience sampling.	2.6.A1.A. Design and conduct an experiment using random sampling.	2.6.G.A. Intentionally Blank	2.6.A2.A. Intentionally Blank	2.6.11.A. Design and conduct an experiment using random sampling.
Organization and Display of Data	2.6.8.B. Organize and display one- variable data using appropriate data display, such as stem-and-leaf and box-and-whisker plots , and two variable data with scatterplots .	2.6.A1.B. Intentionally Blank	2.6.G.B. Intentionally Blank	2.6.A2.B. Intentionally Blank	2.6.11.B. Intentionally Blank
Numerical Summaries	2.6.8.C. Calculate quartiles for one- variable data and describe the correlation coefficient for two- variable data displayed in a scatterplot .	2.6.A1.C. Select or calculate the appropriate measure of central tendency , calculate and apply the interquartile range for one- variable data, and construct a line of best fit and calculate its equation for two- variable data. M11.E.2.1.1 M11.E.2.1.2	2.6.G.C. Intentionally Blank	2.6.A2.C. Construct a line of best fit and calculate its equation for linear and non linear two- variable data.	2.6.11.C. Select or calculate the appropriate measure of central tendency , calculate and apply the interquartile range for one- variable data, and construct a line of best fit and calculate its equation for two- variable data.

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2.6. Statistics and Data Analysis					
	2.6.8. GRADE 8	2.6.A1. ALGEBRA I	2.6.G. GEOMETRY	2.6.A2. ALGEBRA II	2.6.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Statistical Comparisons	2.6.8.D. Compare data sets graphically using double-bar and double-line graphs and numerically using mean, median, mode, range, and quartiles.	2.6.A1.D. Intentionally Blank	2.6.G.D. Intentionally Blank	2.6.A2.D. Intentionally Blank	2.6.11.D. Intentionally Blank
Interpretation of Data	2.6.8.E. Determine the effect of extreme values on numerical summaries and calculate estimates based on survey results or graphs.	2.6.A1.E. Make predictions based on lines of best fit or draw conclusions on the value of a variable in a population based on the results of a sample. M11.E.1.1.2 M11.E.4.1.1 M11.E.4.2.1 M11.E.4.2.2	2.6.G.E. Intentionally Blank	2.6.A2.E. Make predictions based on lines of best fit or draw conclusions on the value of a variable in a population based on the results of a sample. M11.E.1.1.2 M11.E.4.1.1 M11.E.4.2.1 M11.E.4.2.2	2.6.11.E. Make predictions based on lines of best fit or draw conclusions on the value of a variable in a population based on the results of a sample.

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GRADES 8, 11
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2.7. Probability and Predictions					
2.7.8. GRADE 8		2.7.A1. ALGEBRA I	2.7.G. GEOMETRY	2.7.A2. ALGEBRA II	2.7.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Calculate Probabilities	2.7.8.A. Calculate the probability of an event involving “and”, “or” or “not”.	2.7.A1.A. Calculate probabilities for independent, dependent, or compound events. M11.E.3.1.1	2.7.G.A. Use geometric figures and the concept of area to calculate probability.	2.7.A2.A. Use probability to predict the likelihood of an outcome in an experiment.	2.7.11.A. Use probability to predict the likelihood of an outcome in an experiment.
Prediction of Outcomes	2.7.8.B. Intentionally Blank	2.7.A1.B. Intentionally Blank	2.7.G.B. Intentionally Blank	2.7.A2.B. Intentionally Blank	2.7.11.B. Intentionally Blank
Representations of Probabilities	2.7.8.C. Determine the number of combinations and permutations for an event.	2.7.A1.C. Intentionally Blank	2.7.G.C. Compare odds and probability . M11.E.3.1.2	2.7.A2.C. Compare odds and probability .	2.7.11.C. Compare odds and probability .
Display Simple Spaces	2.7.8.D. Intentionally Blank	2.7.A1.D. Intentionally Blank	2.7.G.D. Intentionally Blank	2.7.A2.D. Intentionally Blank	2.7.11.D. Intentionally Blank

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2.7. Probability and Predictions					
2.7.8. GRADE 8		2.7.A1. ALGEBRA I	2.7.G. GEOMETRY	2.7.A2. ALGEBRA II	2.7.11. GRADE 11
Pennsylvania’s public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:					
Compare Theoretical and Experimental Probabilities	2.7.8.E. Find the experimental or theoretical probability of the outcomes of a simple or compound event .	2.7.A1.E. Intentionally Blank	2.7.G.E. Use probability to estimate the areas of complex geometric figures.	2.7.A2.E. Use probability to make judgments about the likelihood of various outcomes.	2.7.11.E. Use probability to make judgments about the likelihood of various outcomes.

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2.8. Algebra and Functions					
2.8.8. GRADE 8		2.8.A1. ALGEBRA I	2.8.G. GEOMETRY	2.8.A2. ALGEBRA II	2.8.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Algebraic Properties	2.8.8.A. Use the concept of equality to demonstrate understanding of the inverse properties of numbers and the addition and multiplication properties of equality.	2.8.A1.A. Intentionally Blank	2.8.G.A. Intentionally Blank	2.8.A2.A. Intentionally Blank	2.8.11.A. Intentionally Blank
Algebraic Manipulations	2.8.8.B. Evaluate and simplify algebraic expressions and solve and graph linear equations and inequalities .	2.8.A1.B. Evaluate and simplify more complicated algebraic expressions and solve and graph linear equations and inequalities . M11.A.2.1.2 M11.A.2.1.3 M11.D.2.1.1 M11.D.2.1.2 M11.D.2.1.3 M11.D.2.1.4 M11.D.2.2.1 M11.D.2.2.2 M11.D.2.2.3 M11.D.3.2.1 M11.D.3.2.2 M11.D.3.2.3	2.8.G.B. Use algebraic representations to solve problems using coordinate Geometry M11.A.2.1.2 M11.A.2.1.3	2.8.A2.B. Evaluate and simplify algebraic expressions and solve and graph linear, quadratic, exponential, and logarithmic equations and inequalities , and solve and graph systems of equations and inequalities . M11.D.2.1.5	2.8.11.B. Evaluate and simplify algebraic expressions and solve and graph linear, quadratic, exponential and logarithmic equations and inequalities , and solve and graph systems of equations and inequalities .

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2.8. Algebra and Functions					
2.8.8. GRADE 8		2.8.A1. ALGEBRA I	2.8.G. GEOMETRY	2.8.A2. ALGEBRA II	2.8.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Patterns	2.8.8.C. Find the missing elements and recognize, describe and extend patterns to include linear , exponential , and simple quadratic equations .	2.8.A1.C. Identify and represent patterns algebraically and/or graphically. M11.D.1.1.1	2.8.G.C. Intentionally Blank	2.8.A2.C. Recognize, describe and generalize patterns using sequences and series to predict long-term outcomes	2.8.11.C. Recognize, describe and generalize patterns using sequences and series to predict long-term outcomes.
Functions	2.8.8.D. Create a table or graph from a functional rule.	2.8.A1.D. Demonstrate an understanding and apply properties of functions (domain , range) and characteristics of linear functions . M11.D.1.1.2 M11.D.1.1.3 M11.D.4.1.1	2.8.G.D. Intentionally Blank	2.8.A2.D. Demonstrate an understanding and apply properties of functions (domain , range , inverses) and characteristics of families of functions (linear , polynomial , rational , trigonometric , exponential , logarithmic).	2.8.11.D. Demonstrate an understanding and apply properties of functions (domain , range , inverses) and characteristics of families of functions (linear , polynomial , rational , trigonometric , exponential , logarithmic).
Modeling	2.8.8.E. Use combinations of symbols and numbers to create expressions , equations in one or two variables , and inequalities in one variable that model problem situations.	2.8.A1.E. Use combinations of symbols and numbers to create expressions , equations , and inequalities in two or more variables , systems of equations and inequalities , and functional relationships that model problem situations.	2.8.G.E. Use combinations of symbols and numbers to create expressions , equations , and inequalities in two or more variables , systems of equations and inequalities , and functional relationships that model geometric situations.	2.8.A2.E. Use combinations of symbols and numbers to create expressions , equations , and inequalities in two or more variables , systems of equations and inequalities , and functional relationships that model problem situations.	2.8.11.E. Use combinations of symbols and numbers to create expressions , equations , and inequalities in two or more variables , systems of equations and inequalities , and functional relationships that model problem situations.

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2.8. Algebra and Functions					
2.8.8. GRADE 8		2.8.A1. ALGEBRA I	2.8.G. GEOMETRY	2.8.A2. ALGEBRA II	2.8.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Interpret Results of Modeling	2.8.8.F. Interpret the results of solving equations in one or two variables and inequalities in one variable in the context of the situation that motivated the model.	2.8.A1.F. Interpret the results of solving equations, inequalities, systems of equations, and inequalities in the context of the situation that motivated the model.	2.8.G.F. Interpret the results of solving equations, inequalities, systems of equations, and inequalities in the context of the situation that motivated the model.	2.8.A2.F. Interpret the results of solving equations, inequalities, systems of equations, and inequalities in the context of the situation that motivated the model.	2.8.11.F. Interpret the results of solving equations, inequalities, systems of equations, and inequalities in the context of the situation that motivated the model.

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2.9. Geometry					
2.9.8. GRADE 8		2.9.A1. ALGEBRA I	2.9.G. GEOMETRY	2.9.A2. ALGEBRA II	2.9.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Definitions, Properties and Relations	2.9.8.A. Name, describe and apply geometric relations for 1-dimensional shapes and 2-dimensional shapes and 3-dimensional solids.	2.9.A1.A. Use algebraic techniques to determine geometric relations of parallel , perpendicular , and finding points of intersections and distances between points. M11.C.3.1.1 M11.C.3.1.2	2.9.G.A. Identify and use properties and relations of geometric figures; create justifications for arguments related to geometric relations. M11.C.1.1.1 M11.C.1.1.2 M11.C.1.2.1 M11.C.1.2.2 M11.C.1.2.3 M11.C.3.1.1 M11.C.3.1.2 M11.C.1.3.1	2.9.A2.A. Use algebraic techniques to determine geometric relations of parallel , perpendicular , and finding points of intersections and distances between points. M11.C.3.1.1 M11.C.3.1.2	2.9.11.A. Create justifications for arguments related to geometric relations.
Transformations and Symmetry	2.9.8.B. Predict and describe the result of a translation (slide), rotation (turn), or reflection (flip) of a 3-dimensional shape.	2.9.A1.B. Intentionally Blank	2.9.G.B. Use arguments based on transformations to establish congruence or similarity of 2- dimensional shapes	2.9.A2.B. Intentionally Blank	2.9.11.B. Use arguments based on transformations to establish congruence or similarity of 2-dimensional shapes

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2.9. Geometry					
2.9.8. GRADE 8		2.9.A1. ALGEBRA I	2.9.G. GEOMETRY	2.9.A2. ALGEBRA II	2.9.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Coordinate Geometry	2.9.8.C. Plot ordered pairs and 2-dimensional shapes that satisfy given conditions on a 2-dimensional coordinate system .	2.9.A1.C. Use techniques from coordinate geometry to establish properties of lines and 2-dimensional shapes and solids. M11.C.3.1.1 M11.C.3.1.2 M11.D.3.2.1	2.9.G.C. Use techniques from coordinate geometry to establish properties of lines, 2-dimensional shapes and solids. M11.C.3.1.1 M11.C.3.1.2 M11.D.3.2.1	2.9.A2.C. Use techniques from coordinate geometry to establish properties of lines, 2-dimensional shapes and solids. M11.C.3.1.1 M11.C.3.1.2 M11.D.3.2.1	2.9.11.C. Use techniques from coordinate geometry to establish properties of lines, shapes and solids.

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2.10. Trigonometry					
2.10.8. GRADE 8		2.10.A1. ALGEBRA I	2.10.G. GEOMETRY	2.10.A2. ALGEBRA II	2.10.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Right Triangle Concepts and Applications	2.10.8.A. Compute measures of sides and angles using proportions , the Pythagorean Theorem and right triangle relationships.	2.10.A1.A. Solve problems arising from the Pythagorean Theorem. M11.C.1.4.1	2.10.G.A. Identify, create, and solve practical problems involving right triangles using the trigonometric ratios and the Pythagorean Theorem.	2.10.A2.A. Identify, create, and solve practical problems involving right triangles using the trigonometric functions and the Pythagorean Theorem.	2.10.11.A. Identify, create, and solve practical problems involving right triangles using the trigonometric functions and the Pythagorean Theorem.
Trigonometric Functions	2.10.8.B. Intentionally Blank	2.10.A1.B. Intentionally Blank	2.10.G.B. Intentionally Blank	2.10.A2.B. Graph periodic and circular functions ; describe properties of the graphs.	2.10.11.B. Graph periodic and circular functions ; describe properties of the graphs.

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2.11. Concepts of Calculus					
2.11.8. GRADE 8		2.11.A1. ALGEBRA I	2.11.G. GEOMETRY	2.11.A2. ALGEBRA II	2.11.11. GRADE 11
<i>Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:</i>					
Extreme Values	2.11.8.A. Analyze graphs of related quantities for minimum and maximum values and justify the findings.	2.11.A1.A. Analyze quadratic functions to determine the location of their vertices; characterize those vertices as maximums or minimums in the context of the problem.	2.11.G.A. Find the measures of the sides of a polygon with a given perimeter that will maximize the area of the polygon.	2.11.A2.A. Determine and interpret maximum and minimum values of a function over a specified interval.	2.11.11.A. Determine and interpret maximum and minimum values of a function over a specified interval.
Rates	2.11.8.B. Describe the concept of unit rate, ratio and slope in the context of rate of change.	2.11.A1.B. Describe rates of change as modeled by linear equations . M11.D.3.1.1	2.11.G.B. Intentionally Blank	2.11.A2.B. Analyze and interpret rates of growth/decay.	2.11.11.B. Analyze and interpret rates of growth/decay.
Accumulation of Areas and Volumes	2.11.8.C. Intentionally Blank	2.11.A1.C. Intentionally Blank	2.11.G.C. Use sums of areas of standard shapes to estimate the areas of complex shapes.	2.11.A2.C. Estimate areas under curves using sums of areas.	2.11.11.C. Estimate areas under curves using sums of areas.

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VI. GLOSSARY

- Absolute Value:** A number's distance from zero on a number line. The absolute value of 2 is equal to the absolute value of -2.
- Algorithm:** A method of performing an arithmetic operation.
- Analog Time:** Time displayed on a timepiece having hour and minute hands.
- Array:** Arrangement of a series of items according to the values of the items (e.g., largest to smallest).
- Associative Property:** A property of addition or multiplication in which the regrouping of the addends or factors does not change the outcome of the operations [i.e., $(a + b) + c = a + (b + c)$ and $(ab)c = a(bc)$].
- Box-and-Whisker Plot:** A graphic method for showing a summary of data using median, quartiles and extremes of data.



- Central Tendency:** The degree of clustering of the values of a statistical distribution that is usually measured by the arithmetic mean, mode, or median.
- Combination:** A subset of the elements in a given set, without regard to the order in which those elements are arranged.
- Commutative Property:** A property of addition or multiplication in which the sum or product stays the same when the order of the addends or factors is changed (i.e., $a + b = b + a$ and $ab = ba$).
- Complementary Event:** The opposite of an event. That is, the set of all outcomes of an experiment that are not included in an event. $P(A') = 1 - P(A)$.

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Complex Numbers:	Any number, real or imaginary, of the form $a + bi$, where a and b are real numbers and $i = -1$.
Composite Number:	Any positive integer exactly divisible by one or more positive integers other than itself and 1.
Compound Event:	An event that consists of two or more simple events; for example: A or B; A and B and C.
Congruent:	Having the same shape and the same size.
Conjecture:	A statement believed to be true but not proved.
Contrapositive:	The implication which results from replacing the antecedent by the negation of the consequent and the consequent by the negation of the antecedent.
Converse:	The theorem (or implication) resulting from interchanging the hypothesis and conclusion.
Coordinate System:	A method of locating points in the plane or in space by means of numbers. A point in the plane is located by its distances from both a horizontal and a vertical line called the axes. The horizontal line is called the x-axis. The vertical line is called the y-axis. The pairs of numbers are called ordered pairs. The first number, called the x-coordinate, designates the distance along the horizontal axis. The second number, called the y-coordinate, designates the distance along the vertical axis. The point at which the two axes intersect has the coordinates (0,0) and is called the origin.
Correlation :	A measure of the mutual relationship between two variables.
Customary System:	A system of weights and measures frequently used in the United States. The basic unit of weight is the pound; the basic unit of capacity is the quart.
Deductive Reasoning:	The process of reasoning from statements accepted as true to reach a conclusion.

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Dependent Event:	The probability of one event depends on the outcome of another event.
Direct Proof:	Uses an argument that makes direct use of the hypothesis and arrives at the conclusion.
Direct Variation:	Two variables are so related that their ratio remains constant.
Distributive Property:	Multiplication is distributive over addition and subtraction [i.e., $a(b + c) = ab + ac$ and $a(b - c) = ab - ac$].
Domain:	The set of all possible values for the unknown in an open sentence.
Equation:	A statement of equality between two mathematical expressions (e.g., $X + 5 = Y - 2$).
Equivalent Forms:	Different forms of numbers that name the same number (e.g., fraction, decimal, percent as $\frac{1}{2}$, .5, 50%).
Expanded Notation:	Involves writing the number in expanded form to show the value of each digit (e.g., $15,629 = 10,000 + 5,000 + 600 + 20 + 9$).
Exponent:	A numeral used to tell how many times a number or variable is used as a factor (e.g., a^2 , 2^n , y^x).
Exponential Function:	A function whose general equation is $y = a \times b^x$ or $y = a \times b^{kx}$, where a, b and k stand for constants.
Exponential Notation:	A way of writing numbers using bases and exponents [e.g., $425 = (4 \times 10^2) + (2 \times 10^1) + (5 \times 10^0)$].
Expression:	A mathematical phrase that can include operations, numerals and variables. In algebraic terms: $2l + 3x$; in numeric terms: $13.4 - 4.7$.
Factor:	The number or variable multiplied in a multiplication expression.

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Factorial:	The expression $n!$ (n factorial) is the product of all the numbers from 1 to n for any positive integer n .
Function:	A relation in which each value of an independent variable is associated with a unique value of the dependent value.
Geoboard:	A board with pegs aligned in grid fashion that permits rubber bands to be wrapped around pegs to form geometric figures.
Graphing Calculator:	A calculator that will store and draw the graphs of several functions at once.
Histogram:	A graphical display that shows frequencies as bars. It shows what proportion of cases fall into each of several categories.
Identity Property:	In addition, adding 0 to a number leaves the number unchanged, or identical ($2+0=2$). Hence, zero is the identity element for addition. In multiplication, the product of any number and 1 is that number ($4 \times 1=4$). Hence, one is the identity element for multiplication.
Independent Events:	Events such that the outcome of the first event has no effect on the probabilities of the outcome of the second event (e.g., two tosses of the same coin are independent events).
Inductive Reasoning:	Generalizations made from particular observations in a common occurrence.
Inequality:	A mathematical sentence that contains a symbol (e.g., $>$, $<$, \geq , \leq or \neq) in which the terms on either side of the symbol are unequal (e.g., $x < y$, $7 > 3$, $n \geq 4$).
Infinite:	Has no end or goes on forever.
Integer:	A number that is a positive whole number, a negative whole number or zero.
Interquartile Range:	The inter-quartile range is a measure of the spread of or dispersion within a data set. It is calculated by taking the difference between the upper and the lower quartiles.

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Inverse:	A new conditional formed by negating both the antecedent and the consequent of a conditional.
Inverse Function:	<p>Formally, suppose f is a one-to-one function with a domain A and range B. The inverse function f^{-1} is a function with these properties:</p> <ul style="list-style-type: none">▪ f^{-1} has domain B and range A.▪ For all x in B, $f(f^{-1}(x)) = x$, or $f \circ f^{-1} = x$ <p>Informally, if f is a function from A to B, then an inverse for f is a function from B to A, with the property that a round trip (a composition) from A to B to A returns each element to itself.</p>
Inverse Operations:	Operations that undo each other (e.g., addition and subtraction are inverse operations; multiplication and division are inverse operations).
Inverse Variation:	When the ratio of one variable to the reciprocal of the other is constant, one of them is said to vary inversely as the other.
Inverse Statement:	Formed by negating the hypothesis and negating the conclusion of the original statement. <i>If p, then q</i> becomes <i>if not p, then not q</i> .
Irrational Number:	A number that cannot be written as a simple fraction. It is an infinite and non-repeating decimal.
Limit:	A number to which the terms of a sequence get closer so that beyond a certain term all terms are as close as desired to that number.
Line of Best Fit:	The line that fits a set of data points with the smallest value for the sum of the squares of the errors (vertical distances) from the data points to the line; the regression line.

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Linear Function:	A function whose general equation is $y = mx + b$, where m and b stand for constants and $m \neq 0$.
Linear Measurement:	Measurement in a straight line.
Logarithm:	The exponent indicating the power to which a fixed number, the base, must be raised to produce a given number. For example, if $n^x = a$, the logarithm of a , with n as the base, is x ; symbolically, $\log_n a = x$. If the base is 10, the log of 100 is 2.
Logarithmic Function:	Any function in which an independent variable appears as the argument in the form of a logarithm; they are the inverse functions of exponential functions.
Manipulatives:	Materials that allow students to explore mathematical concepts in a concrete mode.
Mathematical Model:	A representation in the mathematical world of some phenomenon in the real world. It frequently consists of a function or relation specifying how two variables are related.
Matrix:	A rectangular array of numbers representing such things as the coefficients in a system of equations arranged in rows and columns.
Maximum:	The greatest number in a set of data.
Mean:	The sum of the set of numbers divided by n , the number of numbers in the set.
Median:	The number that lies in the middle when a set of numbers is arranged in order. If there are two middle values, the median is the mean of these values.
Metric System:	A system of measurement used throughout the world based on factors of 10. It includes measures of length, weight and capacity.
Minimum:	The least number in a set of data.

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Missing Addend:	A member of an addition number sentence in which that term is missing (e.g., $5 + \underline{\quad} = 8$).
Mode:	The number(s) that occurs most often in a set of numbers (e.g., in the set 1, 2, 3, 3, 5, 8; the mode is 3).
Models:	Models are representations of real work phenomena. Numerical tables, graphs, equations or systems of equations are all mathematical representations that may be used to model real world phenomena. A good model should capture the essential character of whatever is being modeled.
Multiple:	A number that is the product of a given integer and another integer (e.g., 6 and 9 are multiples of 3).
Normal Curve:	A graphical plot of a mathematical function (frequency distribution) which is unimodal and symmetrical.
One-to-one Correspondence:	When one and only one element of a second set is assigned to an element of a first set, all elements of the second set are assigned, and every element of the first set has an assignment, the mapping is called one-to-one (e.g., in the set Bill Clinton, George Bush, Ronald Reagan, Jimmy Carter, Hillary Clinton, Barbara Bush, Nancy Reagan and Rosalynn Carter, there is a one-to-one correspondence between the pairs).
Open Sentence:	A statement that contains at least one unknown. It becomes true or false when a quantity is substituted for the unknown (e.g., $x + 5 = 9$, $y - 2 = 7$).
Order of Operations:	Rules for evaluating an expression: work first within parentheses; then calculate all powers, from left to right; then do multiplications or divisions, from left to right; then do additions and subtractions, from left to right.
Patterns:	Regularities in situations such as those in nature, events, shapes, designs and sets of numbers (e.g., spirals on pineapples, geometric designs in quilts, the number sequence 3, 6, 9, 12,...).

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Permutation: An arrangement of a given number of objects from a given set in which the order of the objects is significant.

Perpendicular Lines: Two lines that intersect to form right angles (e.g., \perp , \lrcorner , \sqcap).

Plotting Points: Locating points by means of coordinates, or a curve by plotted points, representing an equation by means of a curve so constructed.

Polygon: A union of segments connected end to end, such that each segment intersects exactly two others at its endpoints.



Powers: A number expressed using an exponent. The number 5^3 is read five to the third power or five cubed.

Prime: An integer greater than one whose only positive factors are 1 and itself (e.g., 2, 3, 5, 7, 11, 13, 17, and 19).

Probability: A number from 0 to 1 that indicates how likely something is to happen.

Problem-Solving: Finding ways to reach a goal when no routine path is apparent.

Proof by Contradiction: A proof in which, if s is to be proven, one reasons from not- s until a contradiction is deduced; from this it is concluded that not- s is false, which means that s is true.

Proportion: An equation of the form $\frac{a}{b} = \frac{c}{d}$ that states that the two ratios are equivalent.

Quadrilateral: A four-sided polygon.

Quartiles: The three values that divide an ordered set into four subsets of approximately equal size. The second quartile is the median.

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Radian:	A unit of angular measure equal to $\frac{1}{2\pi}$ of a complete revolution.
Range (1):	The difference between the greatest number and the least number in a set of data.
Range (2):	The set of output values for a function.
Rate of Change:	The limit of the ratio of an increment of the function value at the point to that of the independent variable as the increment of the variable approaches zero.
Ratio:	A comparison of two numbers by division.
Rational numbers:	Any number that can be written in the form $\frac{a}{b}$ where a is any integer and b is any integer except zero.
Real Numbers:	The set consisting of all rational numbers and all irrational numbers.
Reasonableness:	Quality of a solution such that it is not extreme or excessive.
Reciprocal:	The fractional number that results from dividing one by the number.
Rectangular Prism:	A three-dimensional figure whose sides are all rectangles; a box.
Reflection:	A transformation that produces the mirror image of a geometric figure.
Regression:	The line that represents the least deviation from the points in a scatter plot of data.
Regular Polygon:	A polygon in which all sides have the same measure and all angles have the same measure.
Relation:	A set of ordered pairs.
Reliability:	The extent to which a measuring procedure yields the same results on repeated trials.

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Repeated Addition:	A model for multiplication (e.g., $2 + 2 + 2 = 3 \times 2$).
Rotation:	A transformation that maps every point in the plane to its image by rotating the plane around a fixed point or line.
Scatterplot:	A graph of plotted points that show the relationship between two sets of data.
Scientific Calculator:	A calculator that represents very large or very small numbers in scientific notation with the powering, factorial, square root, negative and reciprocal keys.
Scientific Notation:	A way in writing a number of terms of an integer power of 10 multiplied by a number greater than or equal to 1 and less than 10.
Sequence:	A set of ordered quantities (e.g., positive integers).
Series:	The indicated sum of the terms of a sequence.
Similarity:	Having the same shape but not necessarily the same size.
Simple Event:	An event whose probability can be obtained from consideration of a single occurrence (e.g., the tossing of a coin is a simple event).
Simulation:	Modeling a real event without actually observing the event.
Slope:	The slope of a line is the ratio of the change in y to the corresponding change in x; the constant m in the linear function equation; rise/run.
Standard Deviation:	The square root of the variance.

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Stem-and-Leaf Plot: A frequency distribution made by arranging data (e.g., student scores on a test were 98, 96, 85, 93, 83, 87, 85, 87, 93, 75, 77 and 83). This data is displayed in a stem-and-leaf plot below.

```
9 | 8, 6, 3, 3
8 | 7, 7, 5, 5, 3, 3
7 | 7, 5
```

Systems of Equations: Two or more equations that are conditions imposed simultaneously on all the variables, but may or may not have common solutions (e.g., $x + y = 2$, and $3x + 2y = 5$).

Symmetry: A line of symmetry separates a figure into two congruent halves, each of which is a reflection of the other (e.g., \emptyset , the line through the center of the circle divides it into congruent halves).

T-Test: A statistical test done to test the difference of means of two samples.

Tessellation: A repetitive pattern of polygons that covers an area with no holes and no overlaps (e.g., floor tiles).

Transformation: An operation on a geometric figure by which each point gives rise to a unique image.

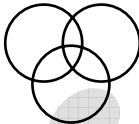
Translation: A transformation that moves a geometric figure by sliding each of the points the same distance in the same direction.

Tree Diagram: A diagram used to show the total number of possible outcomes in a probability experiment.

Trigonometric Functions: A function (e.g., sine, cosine, tangent, cotangent, secant, cosecant) whose independent variable is an angle measure, usually in degrees or radians.

Valid Argument: An argument with the property that no matter what statements are substituted in the premises, the truth value of the form is true. If the premises are true, then the conclusion is true.

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Variable:	A symbol used to stand for any one of a given set of numbers or other objects (e.g., in the equation $y = x + 5$, y and x are variables).
Variance:	In a data set, the sum of the squared deviations divided by one less than the number of elements in the set (sample variance s^2) or by the number of elements in the set (population variance σ^2).
Vector:	A quantity that has both magnitude and direction (e.g., physical quantities such as velocity and force).
Venn Diagram:	<div>A display that pictures unions and intersections of sets. </div>
Volume:	The amount of space enclosed in a space (3-dimensional) figure, measured in cubic units.
Y-Intercept:	The y-intercept of a line is the y-coordinate of the point at which the graph of an equation crosses the y-axis.
π :	pi, the ratio of the circumference of a circle to its diameter: 3.1415926535.